

SECTION 428

VEHICLE, PEDESTRIAN, AND EMERGENCY VEHICLE DETECTORS

428.1 GENERAL: This work shall consist of furnishing and installing vehicle detectors in roadways, pedestrian push buttons on signal standards, and emergency vehicle optical detectors (EVOD) systems at signalized intersections in compliance with the specifications, details shown on the plans, and Standard Drawings, at the locations shown on the plans, or as established by the ENGINEER.

428.2 REFERENCES.

428.2.1 American Society for Testing and Materials (ASTM) Standard Specifications, Latest Edition

D49 Chemical Analysis of Red Lead
D113 Ductility of Bituminous Materials
D150 AC Loss Characteristics
D412 Rubber Properties in Tension
D903 Peel or Striping Strength of Adhesive Bonds
D1190 Concrete Joint Sealer-Hot Poured Elastic Type
D2240 Rubber Property-Durometer Hardness

428.2.2 International Municipal Signal Association (IMSA) Standards, Latest Edition

Official Wire and Cable Specifications

428.2.3 Manual On Uniform Traffic Control Devices (MUTCD), Latest Edition

428.2.4 National Electrical Code (NEC)

428.2.5 National Electrical Manufacturers Association (NEMA) Standards, Latest Edition

428.3 MATERIALS.

428.3.1 LOOP VEHICLE DETECTOR MODULE

428.3.1.1 GENERAL.

428.3.1.1.1 A loop vehicle detector module shall be a self contained, electronic sensing device which registers the presence of a vehicle by recognizing inductance change in a loop of wire embedded in a roadway. The detector module shall be rack mounted in a traffic signal controller cabinet, connected to the cabinet wiring through 44 terminal cinch jones connector (50-44-30m) and wire harnesses. All detector modules shall be the two channel type with independent channel controls. When called for on the plans, each channel shall include a delay/extension time

function.

428.3.1.1.2 All loop vehicle detector modules shall in combination with this specification conform to NEMA Standards Publication TS-1-1989 or latest edition for Traffic Control Systems.

428.3.1.2 DESIGN

428.3.1.2.1 All loop detector modules shall utilize digital design throughout (for threshold, time and cycle calculations). Period measurement, the time elapsed per cycle, or frequency measurement, the cycles counted in a set time interval, may be used as a means to determine a change in inductance.

428.3.1.2.2 The two channel construction shall insure isolation of the channels, to allow elimination of "cross talk" between adjacent loops by frequency selection. Period measurement detectors shall use alternate scanning to accomplish this isolation. Isolation may also be accomplished by sequential excitation and measurement.

428.3.1.2.3 The detector module shall include a fail safe to call feature on each channel to provide a detect output in the event of open circuit loops.

428.3.1.2.4 The minimum composite loop inductive operating range shall be 50-1000 micro-henries and shall allow up to 1000 feet of loop lead-in.

428.3.1.2.5 Detector modules may be self-tuning with automatic tracking or require initial tuning with a minimum automatic drift compensation range of +5 percent after initial adjustment

428.3.1.2.6 Detector module outputs should be optically coupled. The output shall be fail safe (closed) in the event of power loss.

428.3.1.3 OPERATION

428.3.1.3.1 Operational selections or adjustments shall be made by digital or thumb wheel switches on the front panel. A minimum selection of three frequency ranges and three sensitivity (change in inductance) ranges shall be provided along with a presence or pulse output mode and a reset selector. Controls shall be separate and repeated for each channel.

428.3.1.3.2 An output indication (LED) shall be provided for each channel and located on the front panel.

428.3.1.4 DELAY / EXTEND OPERATION

428.3.1.4.1 When specified on the plans, each channel shall include a digital timer to permit delaying or extending detection outputs.

428.3.1.4.2 Loop vehicle detectors shall include switches to select delay, extend/delay time, extension or timer off operation. Minimum range and steps shall be 0-30 seconds in 1-second increments for delay time and 0-7.5 seconds in 0.5-second increments for extend time.

428.3.1.4.3 Output indicators shall display difference in normal detection and delay/extend interval by flashing during this period or by two indicators per channel, separating "Call" and "detect."

428.3.1.4.4 An external input for each channel shall be provided for the state of the green indication of the associated phase. When this "green" input is true, it shall disable delay timing, and when false, extension timing shall be disabled. (When detector logic inhibits times only on application of external signal (115 VAC), connect external input to same phase red when plans call for extend operation.)

428.3.1.5 TWO CHANNEL DETECTOR: On a two (2) channel detector, both channels shall have active power inputs so as to permit either channel to be operated independently without the remaining channel connected. All connector terminal assignments shall comply with NEMA Standards Part 15.

428.3.1.6 LIGHTNING AND TRANSIENT PROTECTION: All detectors shall meet the NEMA requirements for transient testing. This shall be accomplished through the use of MOV(s) for protection from voltage induced in loop lead, installed in cabinet at loop field terminals; flash over protection from internal circuit to ground.

428.3.1.7 TESTING

428.3.1.7.1 The CONTRACTOR shall have the loop vehicle detectors transported to the Traffic Engineering Operations Division at Pino Yard in Albuquerque, New Mexico for testing prior to the ENGINEER's acceptance of compliance with these specifications. Said testing will be effected concurrently with the controller testing under Section 429 - Traffic Actuated Controllers.

428.3.1.7.2 The loop vehicle detectors will be inspected and tested as follows:

428.3.1.7.2.1 Visual inspection for compliance with the specifications and requirements on the plans.

428.3.1.7.2.2 Sample testing for compliance to NEMA standards.

428.3.1.7.2.3 Testing at Traffic Engineering Operations Division and at the completed loop detector installations in accordance to the following. A small vehicle will be simulated by two empty standard steel five-gallon pails each, approximately 12 inches diameter by 19 inches deep and weighing 3.5 pounds held 12 inches over the pavement (SVS--small vehicle simulation).

428.3.1.7.2.3.1 SENSITIVITY TEST: Using four 6-foot by 6-foot, 3-turn loops in series, 100 feet of lead-in cable, hold one pail over center of a loop, then two pails. The detector shall detect at a maximum height of 12 inches and 30 inches, respectively, over the pavement. Repeat using 500 feet of lead-in cable. Using 6-foot by 30-foot, 2-turn (2-4-2) quadruple loop with 100 feet of lead-in cable, carry two pails (SVS) transversely across loop. The detector shall detect and hold the entire distance across the loop at a maximum height of 12 inches. Repeat with 500 feet of lead-in cable. (Actual installation sensitivity tests may be made with the lead-in cable required on the plans, up to 1000 feet and total loop areas not exceeding the special test loops.)

428.3.1.7.2.3.2 HOLD TIME TEST: Under the sensitivity test procedure, an SVS held over the center of each type loop shall provide a continuous detection output for at least 3 ½ minutes.

428.3.1.7.2.3.3 LONG DETECTION AND RECOVERY TEST

428.3.1.7.2.3.3.1 Using a single 6 foot by 6 foot loop or a 6 foot by 30 foot quadruple loop, with sensitivity set for a small vehicle park automobile over loop. The detector shall be capable of holding call for 10 minutes.

428.3.1.7.2.3.3.2 After the automobile is tuned out, remove the automobile and immediately repeat hold time test. The detection shall be dropped and then immediately picked up and held by an SVS.

428.3.1.7.2.3.4 ADJACENT LANE REDUCTION TEST: Using the lowest sensitivity setting that produces detection under the sensitivity test, park an automobile 3 feet from nearest edge of loop(s) and repeat sensitivity test.

428.3.1.7.2.3.5 PULSE MODE REPHASE TEST: Using the detector in pulse mode, park an automobile transversely across the loop(s). Two seconds after the automobile is parked the remainder of the loop shall detect an SVS (generate additional output pulse). Remove the automobile and verify that within one second an SVS is detected.

428.3.1.7.2.3.6 Loop detectors shall perform satisfactorily for the 30-day test period in accordance with the requirements on the plans.

428.3.2 LOOP DETECTOR WIRE (Field)

428.3.2.1 LOOP DETECTOR WIRE: Loop detector wire shall be used for installation in pavement saw cuts. All loop detector wire shall be No. 14 AWG stranded copper wire cross-linked polyethylene (XHHW) insulation conforming to requirements of IMSA Official Wire and Cable Specification 51-3.

428.3.2.2 DUCTED LOOP DETECTOR WIRE: Ducted loop detector wire shall be used for installation in pavement saw cuts or by directly overlaying with paving material. Ducted loop detector wire shall be loop detector wire loosely encased in a polyvinyl chloride or a polyethylene, 0.250 inch O.D. tube. All ducted loop detector wire shall conform to the requirements of IMSA Official Wire and Cable Specification 51-5, except the interior No. 14 AWG stranded conductor may either be insulated with polyvinyl chloride with a nylon jacket (THHN) or polyethylene (XHHW).

428.3.3 LOOP LEAD-IN CABLE: Loop lead-in cable shall be used to connect the loop (installed in the pavement) to the loop detector unit (installed in controller cabinet). Loop lead-in cable shall be No. 16 AWG copper, polyethylene insulated twisted pairs, shielded and enclosed with a polyethylene jacket. All loop lead-in cable shall conform to IMSA Official Wire and Cable Specification 50-2.

428.3.4 LOOP DETECTOR SEALANT

428.3.4.1 Loop detector sealant shall be used as a filler for loop saw cuts, and to secure and protect the loop detector wire. The sealant shall have sufficient strength and hardness to withstand the stress and abrasion subjected by vehicular traffic yet remain flexible enough to provide stress relief under thermal movement. The sealant shall have the ability to bond to both concrete and asphalt, a rapid rate of curing (open to traffic in ½ hour after installation), initial fluidity to permit installation in a narrow saw cut to at least 40°F, moisture insensitivity (apply to damp pavement), and resistance to vehicular fluids and road salt.

428.3.4.1.1 HOT-TYPE APPLICATION: Sealant shall be a hot-melt, rubberized asphalt compound furnished in "bricks" which is formulated specifically to be stiff, non-tracking, flexible at low pavement temperatures, and suited for use as a sealant for traffic loop cuts. At application temperatures, sealant shall be a thin, free flowing fluid which pours easily, penetrates fine cuts, self-levels, and permits easy application. Sealant shall be melted and applied to pavements in accordance with manufacturer's recommendations using either pressure feed melter applicator units or pour pots. After curing, the sealant shall have the following minimum physical and electrical properties:

TEST	ASTM METHOD	MIN.
Penetration, 77°F, (100 g, 5 sec)	D 1190	35 max.
Softening Point		180 ° F min.
Ductility, 77 ° F	D 113	15 cm min.
Mandrel Bend, °F, 180 deg., 5s, ½" dia.	Pass	
Pour Temperature	380 ° F	
Safe Heating Temperature	As specified	

428.3.4.1.2 COLD-TYPE APPLICATION.

428.3.4.1.2.1 Sealant shall be furnished in quart cartridges or 5-gallon pails, and may be applied by conventional cartridge gun or bulk handling pump equipment. The uncured (wet) material shall have a viscosity of 20,000 cps (approximately) at 77°F using a Brook-field Viscometer, #6 spindle at 20 RPM, and have a nonvolatile content (solids) of 75-85% by weight. The material shall cure at a rate to allow, being driven over almost immediately after installation and be dry to the touch within 24 hours. The sealant shall be nonshrinking and remain flexible at temperatures down to -40°F. Sealants shall have the following minimum physical and electrical properties after curing:

TEST	ASTM METHOD	MIN.
Hardness	D 2240	65-85
Tensile Strength	D 412	500 psi
Elongation	D 412	400%
Adhesion (Peel Strength) (canvas to conc.)	D 903	15 lb.
Arc Resistance	D 49	71 secs
Dielectric Strength	D 150	6.35 @ 50 Hz

428.3.4.1.2.2 The CONTRACTOR shall include, with material submittal lists, manufacturer's test data for listed physical properties, and installation recommendations.

When requested by the ENGINEER, the CONTRACTOR shall also furnish a sample for evaluation by the Traffic Engineer. Sealant formulas judged to have failed within one year (either test or permanent installation) shall not be acceptable. Failure shall be considered excessive shrinkage, cracking, peeling and/or bond failures to pavement.

428.3.5 PUSH-BUTTON STATION

428.3.5.1 The housing of the push-button station shall be of substantial tamper proof construction and made of cast aluminum. The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. The housing shall be shaped to fit the curvature of the pole to which it is attached and shall provide a rigid installation. The housing body shall contain a direct push-type actuator button, micro-switch-type or approved equal. The housing cover shall be of the same size and shall contain the push-button sign.

428.3.5.2 Pedestrian push-button signs shall be porcelain enameled sheet steel of 0.036-inch minimum thickness or sheet aluminum of 0.063-inch minimum thickness; 9 inches by 12 inches in size. Each hole shall be provided with a brass grommet if porcelain enameled steel signs are used. Sign corners shall be finished round. Instructions and arrows on the signs shall be black enamel on white enamel background, and the instructions shall be as shown on the plans.

428.3.5.3 Push button housings shall be finished with two coats of best quality infrared oven-baked paint as follows:

428.3.5.3.1 FIRST COAT: Baked epon primer, zinc chromate or equal.

428.3.5.3.2 SECOND COAT: Flat black baked enamel.

428.3.5.4 A single piece cast aluminum pedestrian push-button assembly composed of a push-button assembly, pedestrian sign, sign frame and mounting saddle shall be used when shown on the plans. The push-button shall have silver contacts rated at 35 amps at 12 volts and shall be constructed in such a fashion to prevent vandalism and freezing in inclement weather. The casting shall include a raised legend suitable for visually impaired pedestrians. The single piece pedestrian push-button assembly shall be capable of being attached either by drilling and tapping the mounting surface or by using banding brackets as shown on the plans.

428.3.6 PREFORMED DETECTOR LOOPS.

428.3.6.1 Preformed detector loops shall be factory assembled and shall be asphalt-rubber filled pre-dimensioned loop detectors. The loop shall consist of two or more turns of No. 14 wire with type TFFN insulation. The loop detector wire shall be encased in 3/8 inch polypropylene conduit in the head of the loop. The conduit shall be injected with hot rubber-asphalt sealant to prevent the entrance of water and the movement of wires within the conduit. Inter-loop splicing will not be permitted, but fold points may be provided to facilitate shipping, handling, and installation. Fold points shall occur at not less than six (6) feet nor more than every twenty (20) feet.

428.3.6.2 Conduit used for the loop assembly shall be polypropylene 3/8 inch Copolymer PP SDR-9 molded to the shape required. Typical corner radius on quadruple, diamond, and square shaped loops shall be three (3) inches. The corners shall be hot molded 90 degree bends which are all integral to the loop conduit.

428.3.6.3 Joints shall be located for convenience in shipping and installation. A nominal five (5) inch space shall be provided in the 3/8 inch polypropylene. A sleeve that slides over the space in the 3/8 inch polypropylene shall be a ten (10) inch length of 3/4 inch polypropylene schedule 80.

428.3.6.4 Expansion-contraction joints shall be used at all fold points as specified herein.

428.3.6.5 A Tee shall be used at the center connection on quadrupole shape loops. All Tees shall be CPVC heavy wall injection molded.

428.3.6.6 A flexible 1/2 inch schedule 80 PVC section shall be used to connect the pull Tees to the body of the loop assembly and to the home-run or interconnect. The length of the flexible section shall be as required for proper assembly and to maximize the physical strength of the loop. The flexible Tee section shall have a non-metallic cover made with CPVC and extended skirts with ribbed reinforcing. It shall be made with heavy wall CPVC and have the strength required to withstand construction equipment loading.

428.3.6.7 The side outlets of the Tee body shall be one (1) inch deep and joint with 1/2 inch trade size PVC or CPVC conduit. The center outlet of the Tee shall accept a 3/4 inch trade size conduit. The cover shall be glued onto the Tee body upon completion of the assembly.

428.3.6.8 The completely assembled Tee shall be able to withstand the weight of fully loaded dump and concrete trucks, the tracks of paving machines, and similar

construction vehicles and equipment. It shall not break, crack, or crush when subjected to compressive loading of heavy construction equipment.

428.3.6.9 The field installation of the preformed detector loops shall consist of the routing and placement in existing asphalt pavement during applications of hot asphalt, or prior to concrete paving.

428.3.6.10 All material for assembling and installing the interconnects and home-runs shall be provided directly by the manufacturer. Field assembly of the home-runs and interconnects may result in the conduits being partially sealed when approved by the ENGINEER.

428.3.6.11 The use of factory-sealed home-runs and interconnects shall be used wherever possible.

428.3.6.12 Loop detector, home-runs, and interconnections layouts shall be as recommended by the manufacturer, but shall achieve the traffic lane or movement detection as indicated on the plans and as specified herein.

428.3.6.13 The pull boxes and terminal hand holes shall be installed when called for on the plans, but can be field adjusted for the installation of the home-runs and interconnections for the performed detector loops. However, the field adjustments will require the pull boxes and terminal hand holes to be installed in preformed detector loops. The manufacturer's field positions of the pull boxes and terminal hand holes shall be approved by the ENGINEER.

428.3.7 Microloops

428.3.7.1 Microloops shall be a small, cylindrical unit designed to be installed beneath the road surface which shall be capable of being connected to an inductive loop vehicle detector to provide pulse mode vehicle detection. Microloops shall conform to the following requirements:

428.3.7.1.1 The microloop probe shall be sealed for moisture protection.

428.3.7.1.2 The microloop shall be capable of operating from -35F to +165F.

428.3.7.1.3 The microloop shall have a sensitivity of approximately 3.5 to 8 microhenries/oerstad at 40 KHZ and 0.2 to 0.6 oerstad ambient magnetic field.

428.3.8 EMERGENCY VEHICLE OPTICAL DETECTOR SYSTEMS

428.3.8.1 This work shall consist of furnishing and installing an Emergency Vehicle Optical Detector (EVOD) systems at signalized intersections on signal standards and in control cabinets in compliance with the specifications and the details shown in the plans.

428.3.8.2 The system shall employ optical communication to identify the presence of designated priority vehicles and cause the traffic signal controller to advance or hold a desired traffic signal display selected from phases normally available. The optical signal shall be encoded for vehicle identification and classification. The optical signal shall interface with software for record-keeping, logging, and intersection set-up.

428.3.8.3 The matched set of components which make up the Emergency Vehicle Optical Detector (EVOD) system shall cause the existing traffic controller to be manipulated upon recognition of the signal from the vehicle.

428.3.8.4 This communication shall be effective to the optical detectors at or near the intersection over a line-of-sight path of at least 2500 feet.

428.3.8.5 The EVOD system shall operate on a first come, first-served basis, or on a dual priority basis. The EVOD system shall be designed to yield to other priority demands such as railroad crossings.

428.3.8.6 The EVOD system shall interface with existing traffic signal controllers without compromising normal operation or existing safety provisions. The EVOD system shall consist of an optical emitter, optical detectors, optical detector cable, and encoded phase selectors.

428.3.8.7 To ensure desired performance, the EVOD system shall provide matched system components, proven through integrated testing and extensive functional experience. The matched system components shall offer compatibility with all types of traffic signal controllers, i.e., electromechanical, or solid-state. Matched components shall provide future system compatibility of all priority control elements.

428.3.8.8 EVOD OPTICAL EMITTER ASSEMBLY

428.3.8.8.1 EVOD optical emitters shall be a lightweight, weather resistant, light emitting device with internal regulated power supply.

428.3.8.8.2 The optical emitter assembly shall produce precisely times, crystal controlled optical energy pulses of high intensity light from a single source, at a rate of 14.035Hz or 9.639Hz depending on the emitter control

switch employed. The optical emitter shall send an encoded signal to classify and identify the emergency vehicle.

428.3.8.9 EVOD OPTICAL DETECTOR

428.3.8.9.1 EVOD optical detectors shall be light weight, weatherproof, adjustable, single or dual directional optical detector assemblies.

428.3.8.9.2 Internal circuitry shall transform optical energy from the optical emitter assembly into electrical signals for delivery (up to 1000 feet) via optical detector cable to the phase selection equipment.

428.3.8.9.3 The unit shall be of high impact polycarbonate construction with non-corrosive hardware and shall be designed for simple mounting at or near an intersection on mast arm, pedestal, pipe, or span wire and shall operate over an ambient temperature range of minus thirty degrees (-30°C) to plus sixty (+60°C).

428.3.8.9.4 The unit shall be responsive to the optical emitter at a distance of at least 2500 feet and shall be capable of providing the necessary electrical signal to the phase selector through up to 1000 feet (305m) of optical detector cable.

428.3.8.10 EVOD OPTICAL DETECTOR CABLE

428.3.8.10.1 EVOD optical detector cable shall be durable, and shall have the necessary electrical characteristics to carry power to the optical detector from the phase selector and to carry the optical detector signal to the phase selector.

428.3.8.10.2 The cable shall have three (3) conductors AWG 20 (7 x 28) stranded and an individually tinned drain wire to provide signal integrity and transient protection. Cable conductors shall be copper and shall be shielded with aluminized polyester. The shield wrapping shall have a twenty percent (20%) overlap to ensure shield integrity following conduit and mast arm pulls.

428.3.8.10.3 The cable shall deliver the necessary quality signal from the optical detector to the phase selector over a non-spliced distance of 1000 feet (305m).

428.3.8.10.4 The cable shall deliver sufficient power to the optical detector over a non-spliced distance of 1000 feet (305m).

428.3.8.10.5 The cable insulation rating shall be 600 volts, minimum.

428.3.8.10.6 The cable temperature rating shall be eighty degrees (80°C) minimum.

428.3.8.10.7 The cable shall be color coded as follows:

1. Orange for delivery of optical detector power (+);
2. Blue for optical detector power return (-) or optical detector signal;
3. Yellow for optical detector signal;
4. Bare for optical detector power return (-).

428.3.8.11 PHASE SELECTOR ASSEMBLY

428.3.8.11.1 The EVOD phase selection assembly shall interface between the optical detectors and the controller unit, shall not compromise the existing controller unit's fail-safe provision and shall provide sufficient power for up to three (3) optical detectors per channel.

428.3.8.11.2 The assembly shall provide suitable sensitivity to the optical detector signal, computer software, or encoded emitter on a maintenance vehicle.

428.3.8.11.3 The assembly shall be a plug-in, two (2) channel, dual priority device intended to be installed directly into the input file of control cabinets equipped with priority phase selection software.

428.3.8.11.4 The assembly shall be powered from AC mains and contain an internal, regulated power supply to power optical detectors.

428.3.8.11.5 The assembly shall be capable of recognizing the following pulse rates as delivered by the optical detectors:

1. 9639 ± 0.119 Hz as Frequency I;
2. 14.035 ± 0.255 Hz as Frequency II.

428.3.8.11.6 The assembly shall deliver signals to the controller to cause selection of the desired phase green display for the approaching vehicle.

428.3.8.11.7 The assembly shall have a test switch for each channel to deliver Frequency I or Frequency II signal pulse rates to verify proper function at both optical emitter flash rates, first-come, first-served operation, and Frequency II override capability.

428.3.8.11.8 The assembly shall have a selectable call dropout time of five (5) or ten (10) seconds +2.5%.

428.3.8.11.9 The phase selector shall be a modular, microprocessor controlled, two (2) channel, four (4) phase,

high priority device, expandable to a four (4) channel, eight (8) phase, dual ring controller. The phase selector module shall have memory and shall be programmable via a personal computer. The phase selector module shall have a communication port on the front panel.

428.3.8.11.10 The phase selector shall continuously monitor all GREEN, WALK, and pedestrian clearance displays for a smooth transition from controller to phase selector interval timing.

428.3.8.12 EVOD RELIABILITY

428.3.8.12.1 All equipment supplied as part of the optical priority remote traffic control system intended for use in the controller cabinet shall meet the electrical and environmental specifications spelled out in the NEMA standards publication TSI-1983 part 2.

428.3.8.12.2 All equipment supplied as part of the priority control system intended for use in on emergency vehicles shall operate properly over an ambient temperature range of minus thirty degrees (-30°C) to sixty degrees (60°C) and in air with relative humidity from five percent (5%) to ninety five percent (95%) and a vehicle battery voltage of from ten (10) volts to fifteen (15) volts.

428.4 CONSTRUCTION REQUIREMENTS.

428.4.1 LOOP DETECTOR

428.4.1.1 The installation of a loop detector consists of two distinct elements. The first element is the installation of the loop (inductive coil) in the pavement, at the location and geometry shown on the plans, including a low inductance lead-in cable back to the control cabinet. The second element is the installation of the loop vehicle detector module (sensing unit in the control cabinet, including all wiring to output the presence of a vehicle. Loop detector (total system) installations will not be accepted by the ENGINEER until it is demonstrated that the installation will accurately detect the presence of vehicles as required on the plans and in the specifications.

428.4.1.2 Loop detectors shall be installed in accordance to details on the plans and the following requirements and procedures:

428.4.1.2.1.1 Saw cuts shall be made in pavement of the dimensions and shape detailed in the plans, using an abrasive cutting wheel concrete saw. Saw cut shall be 2¼ inches to 2½ inches deep and approximately 1/4 inch wide. (A 3/8 inch wide slot shall be used to install ducted loop

detector wire).

428.4.1.2.1.2 When a contract includes new pavement or additional paving material overlay, the saw cut and wire installation shall be made at least below the last paving lift of 5/8 inch or greater thickness. No saw cuts will be permitted in final lift of surfacing. In the case of pavement overlay, the saw cut shall be a minimum of 2¼ inches below the final surfacing elevation. When the contract calls for heater scarification pavement treatment, the saw cuts shall be made after this operation has been completed.

428.4.1.2.1.3 Saw cuts intersecting at 40° or more shall be core drilled at intersection point to accommodate wire slack. One-inch to two-inch diameter holes are to be drilled at angle points to the same depth of the saw cuts. Cuts across concrete pavement expansion joints shall also be drilled at this point to allow wire slack. Saw cuts shall overlap by a sufficient length to provide a smooth bottom, even depth wire channel.

428.4.1.2.1.4 When there is more than one loop terminating at a pull box, each loop shall have a separate saw cut back to the box and these saw cuts shall be no closer than 6 inches.

428.4.1.2.2 A separate 1-inch rigid electrical conduit entrance shall be provided at the pull box for each loop. This conduit shall begin at the end of the pavement saw cut and run under any curb and gutter and sidewalk in conformance to the details in the plans. The ends of the conduit shall have all sharp edges removed and shall be "bushed". A 1" - 2" wide hole shall be broken out on the pavement end of the conduit. Wire through this hole shall be left slack and the end of the conduit shall be backfilled and sealed with a soft-setting butyl rubber or asphaltic joint sealer. The remaining portion of the hole shall be filled with the approved saw cut sealant.

428.4.1.2.3 A continuous run of loop detector wire shall be placed in the saw cut, wound around the coil section the number of turns shown on the plans or as directed by the ENGINEER. No more than four wires or turns shall be placed in a single saw cut. Loop detector wire pairs shall be twisted (four to six twists per foot) between the loop (thru the lead-in saw cut and conduit) to the shielded lead-in splice.

428.4.1.2.4.1 Before placement of the sealant and wire, the saw cut shall be cleaned of all debris and standing water by blowing out with compressed air. (The pavement surface may be damp to the touch). The inside of the saw cut shall be free from any sharp protrusions such as from

loose aggregate or uneven saw cuts.

428.4.1.2.4.2 Wire run through drilled corners and joint crossings shall be left slack. This slack portion of wire shall be encapsulated with a soft-setting butyl rubber or asphaltic joint sealer.

428.4.1.2.4.3 The following types of wire installation methods shall be used. (When the plans call for a specific method, only that method will be permitted).

428.4.1.2.4.4 All sealant shall be placed in a saw cut by means of a special nozzle. The saw cut shall be filled to approximately 1/8 inch of the top. No spill over onto the pavement surface will be permitted (any excess shall immediately be struck off). Sealant shall not be placed when the ambient temperature is below 40° F. or manufacturer's requirements, or when precipitation is occurring or impending. The sealant will be considered part of the saw cut operation and no separate payment shall be made therefor.

428.4.1.2.4.5 Ducted loop detector wire may be installed during a paving operation by securely attaching the loop in the proper shape to the pavement surface and overlaying with the next paving lift(s) of 2 inches or greater total thickness. Means of securing the loop, before overlaying, may be by placing the ducted wire in slot cut in the pavement or by securing the corners by a method approved by the ENGINEER, then covering the wire by hand with a small amount of asphaltic paving material. Ducted loop detector wire shall not be bent less than a 1-inch radius.

428.4.1.2.4.6 Preformed loops and microloops shall be placed in accordance with the manufacturer's specifications.

428.4.1.2.5 When a multiple loop system (same channel) is used, adjacent loops shall be wound with opposite rotations. Rotation reversal may be accomplished by reversing leads at the pull box. The CONTRACTOR shall mark the beginning of the loop detector wire and the pull box before beginning the winding installation process to allow determining the direction of rotation. All multiple loops shall be connected in series to the lead-in cable at the pull box or splice point.

428.4.1.2.6.1 Loop lead-in cable shall be run continuously from the loop detector wire splice to the terminal in the control cabinet. No splices in the lead-in cable will be permitted. The drain (ground) wire in the lead-in cable shall be connected to earth ground at the cabinet end only. The ground wire at the curb side pull box

shall be neatly clipped off adjacent to the end of the outer jacket.

428.4.1.2.6.2 Connections between the loop detector wire and the lead-in cable shall be soldered. No open-flame torches shall be used for soldering. The splices shall be made waterproof by encapsulating the bared wire with a two-part sealant, 3-M #3570 connector sealant, or equal. The splices shall then be wrapped with a high quality, all-weather electrical tape or approved self-bonding tape, overlapping the wire insulation approximately 1 inch and of sufficient layers to equal 1½ times the thickness of the original insulation. The outer jacket of the cable shall be sealed in a similar manner except the tape shall overlap the outer jacket by four inches. When ducted loop detector wire is used, sealant shall be applied at the end of the tube portion then wrapped with tape to prevent water entry.

428.4.1.2.6.3 The "V" splices formed shall be suspended high in the pull box to prevent immersion in water.

428.4.1.2.7 After the loop installation in the roadway has been completed, each loop shall be checked with a megger to insure the integrity of the installation. The resistance of each loop shall be greater than 10 megohms at 500 volts. When called for by the ENGINEER, a check will be made of the completed loop detector system in accordance with this Section 428.

428.4.2 PUSH-BUTTON STATIONS: shall be mounted on the side of traffic signal poles as shown in the plans.

428.4.3 EVOD OPTICAL DETECTOR SYSTEM

428.4.3.1 EVOD optical detector systems shall be installed in accordance with the manufacturer's recommendations. The equipment manufacturer shall not modify the existing traffic controller unit beyond adding the necessary hardware to the traffic controller cabinet.

428.4.3.2 The manufacturer or its authorized representative shall be responsible for system check-out prior to purchaser's acceptance by verifying proper installation per recommended interfaces, verifying that optical ranges are properly set, and verifying that phase selector timings or controller software timings are properly set.

428.4.3.3 The CONTRACTOR shall provide appropriate training for the Traffic Engineer's personnel and emergency vehicle operators, and assist in trouble shooting, maintenance, and system operation.

428.5 MEASUREMENT AND PAYMENT.

428.5.1 Loop vehicle detector modules, preformed loops including lead, microloops, and push-button stations will be measured by the unit complete in place.

428.5.2 Loop detector wire, ducted loop detector wire, loop lead-in cable, and loop detector saw cut will be measured by the linear foot complete in place.

428.5.3 Emergency vehicle optical detector system components including phase selector racks, phase selector modules, "D" panels (including cables and harnesses), optical detectors, and optical emitters will be measured by the unit complete in place. Optical detector cable will be measured by the linear foot complete in place.

428.5.4 The accepted quantities of loop vehicle detector modules, preformed loops, microloops, push-button stations, loop detector wire, ducted loop detector wire, loop lead-in cable, loop detector saw cut, and emergency vehicle optical detector system components including phase selector racks, phase selector modules, "D" Panels (including cables and harnesses), optical detectors, optical emitters, and optical detector cable will be paid for at the contract unit price per unit of measurement for each of the pay items listed as shown on the bid proposal.